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Impulse control systems for servomechanisms with nonlinear friction

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IMPULSE CONTROL SYSTEMS FOR SERVOMECHANISMS WITH NONLINEAR FRICTION

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THESIS CERTIFICATION

I, Stephen van Duin declare that this thesis submitted in fulfilment of the requirements for the award of Doctor of Philosophy in the School of Electrical, Computer and Telecommunications Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualification at any other academic institution.

Stephen van Duin

30th August 2006

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LIST OF ABBREVIATIONS

DC – Direct Current

DSP – Digital Signal Processing

emf – Electro-Magnetic Force

FFT – Fast Fourier Transform

IAE – Integral of the Absolute Error

PC - Personal Computer

PCD – Pitch Circle Diameter

PD – Proportional Derivative

PDTV – Position Dependent Torque Variation

PID – Proportional Integral Derivative

PWMH – Pulse Width Modulated Sampled Data Hold

SCARA – Selective Compliant Assembly Robot Arm

Sgn – Sign function

Stiction – Static Friction

TCP – Tool Centre Point

ABSTRACT

At low velocities, friction is highly non linear and difficult to control. In practical mechanisms, friction may also be position dependent and highly variable. This can lead to tracking errors, limit cycles, and a phenomenon referred to as ‘stick-slip’, when a periodic cycle of alternating motion and rest, limits the mechanism’s velocity and position accuracy.

Impulse control is a friction compensator that does not require an accurate friction model. It achieves precise motion of a servomechanism by applying small impacts which overcome static friction with a controlled breakaway. The size of the impact and its duration determine how much the mechanism moves. By controlling the pulse, the positional accuracy of the mechanism can be improved.

The work presented in this thesis results in new impulse controllers which: 1) improve the precision of a servomechanism without mechanical modification for the tasks of position pointing and low speed position tracking; 2) eliminate phenomena such as stick-slip, quadrant glitch, and limit cycling; 3) minimise system vibration and low speed position tracking ripple.

The new controllers are tested by simulations, and experimentally verified on two different mechanical systems. One of these is a test bed built specifically for friction control experiments, and the other is a SCARA robot manipulator.

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